In situ UHVEM study of {113}-defect formation in Si nanowires

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High fluxes of electrons with energies above 200 keV can create self-interstitial clusters in thin Si and Ge foils. In TEM, these clusters are observed as so called {113}-defects with {113}-habit planes and elongated along <110>-directions. Previous studies on bulk material showed that dopants, capping layers and local stress fields influence the defect formation kinetics and stability.

Results are presented on in situ {113}-defect formation during UHVEM irradiation of Si nanowires with diameters between 40 and 500 nm. The Si nanowires are part of TFET structures and their top is p^+-type (> 5×10^{19} B cm^{-3}) either by epitaxy or by ion implantation. The nanowires are embedded in SiO_2 covered with other capping layers and are etched into a stack consisting of an n^--type (10^{17} As cm^{-3}) epitaxial layer grown on a n^+-type substrate (2×10^{19} As cm^{-3}).

The UHVEM of Osaka university is equipped with an ion trap and is using an oil-free vacuum system so that both the e-beam and the vacuum in the specimen chamber (about $7\cdot10^{-6}$ Pa) are very pure and possible contamination related influences on intrinsic point defect cluster nucleation and growth are reduced to a minimum. This allows in situ study of the formation of self-interstitial clusters while varying the e-beam flux and irradiation temperature over a wide range.

In situ irradiations are performed on cross-section samples with thicknesses ranging from 50 to 400 nm prepared by FIB. Samples are irradiated with different fluxes of 2 MeV electrons at temperatures between room temperature and 375 ºC. A strong dependence of {113}-defect formation on nanowire radius and dopant concentration and type is observed as well as on specimen thickness. The observations are compared with simulations based on quasi-chemical reaction rate theory and with results from scanning spreading resistance microscopy and from earlier work on bulk material.